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JOINT MEETING
SECTION OF GEOLOGY AND MINERALOGY
AND
SECTION OF BIOLOGY

DECEMBER 4, 1944

DR. CARL O. DUNBAR, Professor of Paleontology and Director of Peabody Museum, Yale University: *The Geologic and Biologic Significance of the Evolution of the Fusulinidae.* (This lecture was illustrated with lantern slides.)

The Fusulinidae comprise a well defined family of the Foraminifera found in great abundance in the later Paleozoic rocks. They appeared near the beginning of Pennsylvanian time and lived through until late in the Permian, commonly existing in such numbers in the shallow seas of the Northern Hemisphere as to be important rock makers. They are thus among the commonest and most characteristic marine fossils of a number of the great coal and oil fields of the world. Because of their small size and vast numbers, they are easily recovered from well cores or even from drill cuttings, and so are especially useful in subsurface correlations.

Their usefulness in this way stems largely from the fact that their shells are complicated and, throughout the geologic range of the family, were undergoing very rapid evolution. This involved, among other things, a tendency toward greater and greater size and the progressive

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change in several shell features. A knowledge of these evolutionary trends, once it is integrated to the stratigraphic record, permits one to recognize the geologic horizon and to make correlations over great distances, even without the identification of species.

The fusulines are relative giants among the Foraminifera, commonly resembling grains of wheat or oats in size and shape, but ranging upward to subcylindrical shells as thick as a lead pencil and two inches in length. Compared with *Amoeba* or *Globigerina*, one of these largest forms would appear like a *Brontosaurus* of the protozoan world!

The fusuline shell is planispirally coiled about an elongate axis and is typically fusiform. Indeed, the original genus, *Fusulina*, was so named because of its shape, and most of the other genera agree with it in this respect, though with variations ranging to subcylindrical on the one hand and to subspherical or even lenticular on the other.

The spiral wall of these shells developed an amazingly complicated structure. Moreover, the whorls are subdivided by numerous radially disposed septa into slender meridional chambers. These septal plates, at first plane and simple, display various types of specialization. Secondary shelly deposits tended to form in characteristic but changing patterns; and the meridional chambers, primitively slender and simple, became subdivided into many chamberlets. All this complicated internal architecture is invisible from the exterior, and shells that appear superficially alike may be utterly dissimilar internally. For this reason, critical study of a fusuline requires at least two carefully oriented thin sections of the shell, one following the axis and the other the sagittal plane, both of them passing through the initial chamber. Cutting of such sections is a tedious task calling for skill and experience, and is one of the chief obstacles in the study of the fusulines.

In the evolution from primitively small and simple to relatively large and structurally complicated shells, several different structures were involved and each shows definite evolutionary trends more or less independent of the others. Some of these indicate a slow orthogenetic change persisting throughout a considerable amount of geologic time—a change of the sort displayed in the evolution of the horse from his pentadactyl and plantigrade ancestor to the unidactyl and unguligrade animal of the modern world. Such changes were transpiring simultaneously in various parts of the world and, in the case of the horse, clearly resulted in more perfect adaptation of the animal to its environment. One is tempted to infer that the major evolutionary changes

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displayed by the fusulines also were, in general, adaptive; even though the environmental factors that gave them survival value are, in some respects, obscure.

One of the major changes had to do with the mural pores. In primitive genera—all those characteristic of the lower half of the Pennsylvanian system—these are microscopic capillary tubes having a diameter of only 1 to 3 microns and, therefore, being difficult to detect in ordinary thin sections. But near the middle of the Pennsylvanian period (i. e., late in the Des Moines epoch), the mural pores began to enlarge and, in shells of that age, they are commonly visible though still tubular. A rapid change followed, in which the main layer of the wall thickened and the mural pores enlarged into alveoli, like the cells in honey-comb, remaining fine only in a thin outer film of the wall (the tectum). The net result was to produce a relatively thick wall having the maximum rigidity attainable with a given amount of shell material, or the least possible weight capable of yielding a given amount of rigidity. The frequent discovery of specimens that were broken and healed during life suggests that the strength of the shell was frequently taxed; and, since all the genera that include large species have the alveolar type of shell wall, we may infer that lightness of contruction may have been a factor in limiting the growth of such unicellular animals.

The gradual development of septal folds is one of the striking evolutionary trends in the subfamilies Fusulininae and Schwagerininae, where it results in great strength with a minimum of weight, on the same principle that makes a corrugated paper carton light and strong. Curiously, the Oriental subfamily Neoschwagerininae achieved the same end in a quite different way. Successive stages in septal evolution can be used to distinguish several stratigraphic horizons.

Secondary shell deposits occur in many of the fusulines, but their characteristic distribution within the shell displayed systematic changes in the course of time. A knowledge of these changes also can be effectively used as a check on the geologic age.

At the beginning of the Permian period, two new genera of fusulines appeared, each of which is characterized by a very rapid increase in the height of its chambers at a certain stage in its ontogeny. There are *Pseudoschwagerina*, derived out of *Triticites*, and *Paraschwagerina* derived out of *Schwagerina*. In both, the early whorls are closely coiled as in other genera of fusulines; but, after this ontoge-

netic stage, the next whorl rapidly increases in height and the shell becomes inflated and commonly subspherical. Both these genera were enormously successful for a time, spreading rapidly throughout the seas of the Northern Hemisphere. Each had a rather short career, dying out without issue at the end of the Wolfcamp epoch. One is tempted to think that the sudden inflation of the shell marks an adaptation to pelagic life, the expanded chambers having been partly filled with gas as is the final chamber in the living foraminifer *Tretomphalus bulloides*.[1] This possibility may be indicated by the fact that the spiral wall of these inflated genera is much thinner than that of the parent genera, that these inflated shells are never weighted down with secondary shelly material, as are many species of the contemporaneous genus *Schwagerina*, and that they are so widely distributed.

[1] **Myers, Earl H.** Biology, Ecology, and Morphology of a Pelagic Foraminifer. Stanford University Publications, Biol. Ser. 9 (1): 1–30. 1943.

SECTION OF PSYCHOLOGY

DECEMBER 18, 1944

DOCTOR JULES H. MASSERMAN, Division of Psychiatry and the Otho S. A. Sprague Institute, University of Chicago, Chicago, Ill.: *The Biodynamics of Experimental Neuroses and Alcoholism.* (This lecture was illustrated by motion pictures.)

I don't believe it is necessary for me to express in words the deep appreciation I feel for this opportunity to address the Academy. Certainly, my presence here, this evening, despite every obstacle of crowded duties and difficulties of travel, should convey the fact that I consider this a signal—though undeserved—honor. And I shall try to show my appreciation concretely by fulfilling, as nearly as I can, the purpose for which, I presume, I was invited: namely, to present a concise over-all survey of our work on experimental neuroses at The University of Chicago, including the recent studies on alcohol which supply the title to this paper. With your permission, then, I shall omit technical descriptions of our methods or detailed analyses of our results, in the form of tables, graphs or mathematical derivatives, which, though entrancingly exact in form, are often dubious in meaning. Instead, I shall try, later on, to substantiate my statements by employing what is in many respects the most objective as well as the least tedious way of presenting vital data: i.e., by showing a motion picture film of some of the actual experiments under discussion.

THE HYPOTHALAMUS

Let me, then, sketch as briefly as possible the developmental background of our studies. About a decade ago, my student associates and I began to correlate our clinical psychiatric work with parallel experimentation in animal behavior, in the hope of discovering biodynamic principles broad enough to cover the conduct of both animals and men. In line with these interests, it was our purpose to study those aspects of behavior that were of greatest significance from a psychiatric standpoint, namely: its biologic, motivational and emotional determinants. Our first experiments, accordingly, were concerned with a so-called "psychosomatic" theory which at that time seemed to be gaining headway among some physiologists and psychiatrists. In substance, this

theory held that motivations and emotions had their origin in the neural and hormonal functions of the hypothalamus—a tiny neural structure that thereby embodied the solution (as per *circa* 1935) of the body-mind problem and, in effect, represented the end of the ancient quest for the "seat of the soul." Purported evidence for this concept of hypothalamic function was derived mainly from what proved to be certain unwarranted interpretations of the brilliant work of Karplus and Kreidl, Cannon and Britton, Bard, Ranson, Rioch and others. These investigators, in brief, had shown that stimulation of the hypothalamus in animals produced the peripheral expressions of what Bard rightly called the pseudo-affective state of "sham rage," whereas lesions of the hypothalamus rendered the animal for a time emotionally apathetic. I shall not go into an extensive exposition of our own experiments in this field, since they have already been filmed and reported in, perhaps, too great detail elsewhere,* but certain of our results may be briefly reviewed as relevant to the present discussion. In short, we found that the dramatic "sham rage" responses produced by electrical or pharmacologic stimulation of the hypothalamus, unlike those in true affective states, were mechanical, unadaptive and did not interfere with ordinary goal-directed behavior such as conditioned food-taking; whereas, unlike true rage or fear, these pseudo-affective responses could not be conditioned to situational stimuli. Conversely, animals rendered apathetic by destruction of the hypothalamus regained their normal emotional responses as soon as they recovered from the metabolic disturbances produced by the initial neurologic lesions. These and other experiments indicated that motivation and emotion are not to be localized in particular body structures, nerve pathways or blood hormones, but are expressions of holistic adaptations to the total field of the organism.

Our further work, therefore, entailed the development of techniques that would make possible the study of the motivations, field organization and general adaptive nature of total behavior—terms that I hope to make clear as this discussion develops. For this purpose, as you will see in the films, we designed and built an apparatus that made possible a wide variety of controlled experimental procedures, such as: (1) the use of known incentives to action; (2) the employment of field

* For an extensive bibliography and discussion, see **Masserman, J.**, "Behavior and Neurosis," Chicago, University of Chicago Press, 1943. The experiments themselves are recorded in several teaching motion picture films from the Division of Psychiatry of the University of Chicago, distributed by the Psychological Cinema Register, State College, Pa.

symbolizations to "condition" specific adaptive patterns; (3) the interposition of physical obstacles or "social" frustrations; and, finally, (4) the elicitation of simultaneous but incompatible responses in order to study their disruptive effects on the animal's behavior. Let me now describe some of our basic observations with these procedures as employed with some two hundred and fifty animals during the past six years.

Experiments in the Biodynamics of Behavior

Motivation and Symbolic Adaptation

In our early experiments we found that a cat or a dog could easily be taught to lift the lid of a food box to secure a pellet of food, and then further trained to delay this response until a bell or a light signal had been given. During this period, the animal readily entered the apparatus, responded avidly to the signals *until it wanted no more pellets* and, throughout, remained on the best of terms with the experimenter.

Development of Complex Action Sequences in Adaptive Behavior

The animal could next be trained to depress a pedestal switch to actuate the feeding signals and so secure food at will. Finally, this adaptive behavior could be made progressively more complex by interposing barriers or by making the switch manipulation more difficult up to the limits of the perceptive and adaptive capacities of the animal. For instance, one cat was taught to pass a barrier twice and depress the switch three times in various positions before attempting to feed,—a level of performance which placed the animal in the "genius" bracket of the general cat population. Significantly, if the circuit was disconnected so that the feeding signals were not actuated when the switch was depressed, the total adaptations of the animal were in most cases disrupted, so that it did not attempt to secure food freely available in the box until the proper feeding signals were again interposed. However, as long as the environment remained organized and experimentally predictable, the animal went contentedly about its task of working the switch, responding to the signals and earning its living in its accustomed ways.

Effects of Frustration

If the food box were locked or barriers were so placed that an

animal was deprived of its reward after working the switch, the animal at first attacked the obstacles in its path with an intensity roughly proportional to its degree of hunger motivation. When these attacks did not succeed, it showed interesting explorations in *substitutive activity:* for instance, it would press down on ropes or other objects in its cage instead of the signal switch, or it would reach for the lights and bell in lieu of the unobtainable food. In this connection, a particularly significant form of substitutive aggressivity between one animal and another appeared in circumstances of "social thwarting" which could be arranged experimentally as follows:

Dominance and Aggression

Two trained cats were placed in the cage together and given only a single pellet after each feeding signal. Under such conditions, the more alert and active of the two pre-empted the pellet, whereas the other, with little or no fighting, soon ceased to respond to the signals and thereafter surrendered the food rewards to its dominant partner. In this way, an "hierarchy of privilege" could be set up in a group of two, three or four cats, so that the second in line attempted to feed only when the dominant one was removed; the third, only when the top two were gone; and the last, only when it was alone in the cage. When, however, an animal accustomed to dominance was superseded by an even more dominant animal from another group, the displaced animal ceased to respond to the signals, but appeared to find substitutive outlets in the form of violently aggressive attacks on the interloper. Significantly, also, the newly dominant animal in the group rarely responded with counter-aggressions as long as it had free access to the food-rewards, but when it, also, was socially thwarted in this goal-directed activity, it, too, became deviantly aggressive.

Other and even more interesting patterns of inter-cat relationships developed when two animals trained in the use of the signal switch were placed together, with the apparatus so arranged that the animal which worked the switch could not secure the single pellet before its partner did so. In such circumstances, some animals for a time worked the switch alternately so as to feed each other, but sooner or later this arrangement broke down and one of the animals began to shirk its share of the work to become "parasitic" on the other. In most pairs, however, the "worker," too, later quit for lack of reward, and then both animals lay about starving rather than attempt further cooperation.

Often, however, the worker, by turning his aggressions on the switch, learned that if he attacked it violently enough so that many pellets fell into the box, he could get some before the parasitic animal had consumed them all. From then on, he generally continued to work the switch many times, got a part of the proceeds for his efforts, and so once again stabilized the situation. Observations even at this level of animal relationships, therefore, seemed to support the sociological dictum that individuals in groups tend to fall into hierarchies of dominance-submission and worker-parasitism, and that aggressions appear in an individual subjected to social displacement and frustration. Our studies in these respects, then, confirmed and extended the observations of Mowrer,* and supported the conclusions he presented before this Academy some four years ago.

Experimental Neuroses

One other aspect of our recent work also has an immediate bearing on our discussion tonight, namely: the production of experimental neuroses in animals by the method of inducing conflictful motivations leading to disparate and incompatible adaptive patterns. A typical experiment may be described as follows:

An animal is trained to depress a signal switch before opening a box for a pellet of food. Just as the animal is about to secure its reward, however, a blast of air is unexpectedly blown across the box, or a mild condenser shock is administered through the grill floor of the cage. The animal recoils at this disturbing experience, but, after some hesitation, again essays to feed at the signal. This is permitted a few times but, later, and again unexpectedly, the air blast or shock is repeated. Eventually, then, the hungry animal must face a motivationally insoluble problem. Each signal indicates that food is available if the animal were to open the box as usual, but now the same signal also represents (or "means") an intolerable self-frustration in either feeding or escape. In this dilemma, the animal develops aberrations of conduct that correspond so closely to the phenomena of human neuroses that I have dared the wrath of my psychoanalytic friends by describing them in clinical terms. For instance, the animal develops feeding inhibitions or selective avoidances of such severity that it may starve itself into a near-fatal cachexia rather than take readily available food in or

* Mowrer, O. H. Animal Studies in the Geneses of Personality. Tr. New York Acad. Sci. Ser. II, 3 (1). 1941.

out of the experimental situation. Again, it exhibits every physiologic evidence of anxiety in sensorial fields associated with the experimentally induced conflict. For instance, it shows sudden startled reactions, tachycardia and respiratory disturbances, when subjected to light or sound stimuli reminiscent of the feeding signals, or it becomes claustrophobically panic-stricken, if constricted into small spaces. Similarly, it may develop peculiarly stereotyped compulsive and counterphobic patterns, such as starting with blank immobility into the food-box without appearing to notice the food, or passing barriers aimlessly in a ritualized, stereotyped fashion. If more severely neurotic, it may become subject to various motor disturbances such as tics, repetitive movements, regressions to earlier forms of behavior, or even cataleptic rigidity. Concurrently, it loses dominance in its group hierarchy, while its relationships to the experimenter become altered either toward extreme dependence or aggressive hostility.

The Biodynamics of Therapy

The experimental methods that were found to be effective in alleviating these neurotic aberrations of behavior in our animals likewise seemed heuristically significant, in that they were operationally successful only in so far as they relieved the motivational conflict basic to the neurosis. Since there were seven of these "therapeutic" methods, and I am scheduled tonight to devote particular attention to the last of them—the use of alcohol and other drugs—I shall not presume upon your time by dwelling at length on all seven; however, perhaps their mere enumeration may serve to point out how closely they correspond to the techniques employed in the clinical therapy of human neuroses. Briefly, the methods are these:

First, providing the animal with a prolonged *vacation* from the conflict-producing situation amid relatively restful surroundings. This method, however, is slow, uncertain and does not prevent recurrences of neurotic behavior when the animal is again exposed to conflict. Incidentally, the author, his home and his domestic tranquility have suffered considerably from attempts to provide a rest-haven for neurotic animals.

Second, affording the animal some physiologic *relief from one of the conflictful drives.* For instance, if the hungry neurotic animal is fed before replacing it in the experimental situation, its anxiety and

phobic reactions are considerably diminished.

Third, the utilization of what might be called *transference relationships* to guide the animal out of its motivational impassé. Thus, an experimenter, whom a neurotic animal had previously learned to trust, may retrain it in gentle stages to re-explore the feeding situation, once again respond to signals and, finally, even withstand the conflict-engendering trauma. Conversely, if the animal's confidence in the experimenter is not first re-established, the retraining is difficult and ineffective.

Fourth, the use of some *environmental press* which, for instance, inexorably forces a starving neurotic animal to eat, despite its phobias and inhibitions. Again, this method is successful only in mild neuroses or if the animal is exceptionally well-integrated; in other cases, the animal may be driven into an almost uncontrollable panic.

Fifth, the employment of *"social example."* In this technique, a neurotic animal is placed in the cage with one that is responding normally to the feeding signals. In such circumstances, some neurotic animals may slowly overcome their own inhibitions and begin to emulate the behavior of their normal partners; at first, when they are together, and finally, when they are apart.

Sixth, and most effective, the *spontaneous working-through of the conflict-situation.* An animal that has learned the use of the switch and and is then made neurotic will, for a time, show a peculiar amnesia for the switch-manipulating pattern. However, as its hunger mounts from day to day, the animal may tentatively re-explore the use of the switch to secure food at optimum moments; and, in this way, gradually utilize what control it had previously attained over its environment to "work through" and establish anew normally goal-directed patterns of behavior. Once this is done, moreover, the animal is relatively immune to further traumata of a similar nature.

The seventh and final mode of therapy is the *administration of drugs that impair apperceptive discriminations and thereby diminish the acuteness of the adaptational conflict.* This is the method that I shall discuss later in particular connection with the effects of alcohol and their relationships to the dynamics of experimental neuroses. Before doing so, however, it may be well to summarize the significance of the experimental data so far presented and to correlate them with everyday clinical observations of what Adolf Meyer has well called "the experiments of nature in human behavior." May I, then, submit

to you four biodynamic generalizations which, I believe, apply to human beings as well as experimental animals, and which will be elaborated in my book, "Principles of Dynamic Psychiatry," now nearing completion? Each canon, of course, has numerous corollaries and qualifying codicils; but, in briefest statement, they are these:

The Biodynamic Principles of Behavior

1. Behavior is motivated by the physiologic needs of the organism.
2. The animal responds, not to "objective" reality, but to its own experientially determined *interpretations* of its milieu.
3. Under conditions of frustration, behavior becomes deviant and substitutive or "symbolic."
4. In circumstances that produce motivational conflict, behavior becomes ambivalent, inhibited, vacillating, stereotyped and excessively substitutive and symbolic—or, in clinical terms, "neurotic" or "psychotic."

* * * * *

This, then, is an exceedingly condensed survey of a decade of experimental work with hundreds of animals, and of what I believe to be the biodynamic integrations of our results with clinical and psychoanalytic observations of human behavior. On the one hand, I fear that my summary may have been telescoped beyond the point of adequate clarity and coherence. On the other, it might seem a rather elaborate prologue for the special studies on alcohol, were it not for two saving considerations: first, that it provided the rationale and the necessary central observations for these studies, and, second, that their presentation is to be mainly in the form of a motion picture, which, I hope, will vivify the actual experiments and their results. It remains, then, only to outline and, for purposes of accuracy, to qualify statistically what you will see illustrated.

Neurosis and Alcohol

Technique of the Experiments. As already described, a cat is trained in the experimental apparatus to pass various barriers and manipulate a signal switch preparatory to opening a box for the food reward. The effects of graded doses of alcohol on these normal adaptive patterns is then studied, after which the animal is made neurotic by a motivational conflict and again given alcohol. Finally, it is

permitted free access to alcohol to see if a spontaneous preference for the drug develops.

Results: Briefly, the results are these. When an animal is given from 0.7 to 2.0 cc. per kilo of alcohol, its most recently acquired and complex discrimination-response patterns (e.g., difficult switch-manipulations) are progressively disorganized until only the most primitive and elemental reactions remain. Conversely, as the animal emerges from alcoholic stupor, its adaptive capacities gradually become reconstituted until the highest orders of learned behavior again appear.

If now the animal is made neurotic and once more given alcohol in small doses of 0.5 to 1.2 cc. per kilo, essentially the same effects appear, but in an interestingly deviated form of expression. Thus, the inhibitions, phobias, loss of group dominance, compulsions, and other aberrant behavior patterns—i.e., those which constitute the most complex reactions to the conflict-producing situation—are again the ones first disintegrated, leaving the earlier signal-response and feeding patterns relatively intact. In our experiments, then, small doses of alcohol, by impairing discrimination and hypersensitivity of reaction, seemed to have an actually beneficial effect on neurotic behavior, although, of course, the inhibitions and other neurotic symptoms returned as the effects of the drug wore off. But here is where still another unexpected phenomenon appeared: twelve of the twenty-one animals which had experienced temporary relief of neuroses under alcohol, and which had previously refused to take alcohol spontaneously, now began to prefer food containing alcohol and thus, to all intents and purposes, became alcoholic "addicts." Interestingly, too, this preference rapidly abated as their neurosis was relieved either through spontaneous re-exploration of the conflict situation while they were intoxicated, or by the use of vacations, environmental press, retraining, or one of the other therapeutic methods previously described.

Effects of Alcohol in Mitigating the Neurotogenic Effects of Motivational Conflicts

The next question that naturally arose was: if alcohol, by impairing the acuity of discrimination, disorganizes neurotic behavior patterns, should not the drug also protect the animal from the effects of the conflictful experience itself? To this question, our experiments

have not yet given an unequivocal answer, and I can only report our results to date. Of nine cats given 0.5 to 1.5 cc. per kilo of alcohol and then subjected to an air-blast or electric shock during conditional food-taking, only four have reacted with the development of definitely neurotic symptoms, and, even in these, the behavioral aberrations have been either evanescent or considerably milder than in previous control animals not given alcohol. In contrast, the five other animals have shown a curious bravado and a remarkable immunity to motivational conflicts while intoxicated. For instance, three of them seemed relatively undisturbed by electric shocks strong enough to produce myoclonus, and two of them, instead of running in panic from the air-blast, would actually approach, sniff and play with the pneumatic tube. However, these few observations cannot yet be taken as determinative, since not only must a larger series of animals be investigated, but each one must later be made to serve as its own control by being subjected to the traumatic situation when not intoxicated. If then they develop definite neuroses, the experiments will assume significance and definite conclusions can be drawn.

Permit me now, before proceeding to a final brief discussion of these findings, to illustrate the work on experimental neuroses and on alcohol by the showing of a motion picture film that may, at last, give some substances to this discourse.

(Showing of motion picture film "Neurosis and Alcohol."*)

Discussion

Naturally, I recognize the vast differences between the most intelligent of alcoholic cats and the humblest of human topers. It seems hardly necessary to point out here that—even though the human being has a far greater capacity for complex perceptions, symbolizations and integrations, and a far larger repertoire of normal and neurotic adaptations—from an objective scientific viewpoint, he is still an animal whose behavior conforms to general biologic and biodynamic principles. It is these general principles that our work attempts, however remotely, to approach. And so we can, with considerable relevance, point out that the human being, too (as, for instance, a combat flier after a sortie), often resorts to alcohol to diminish the anticipated poignancy of a conflictful situation, and that, from a psychiatric standpoint,

* Prepared by the Division of Psychiatry, University of Chicago; distributed by the Psychological Cinema Register, State College, Pa.

chronic alcoholic addiction is very often a symptomatic escape from underlying neurotic anxiety. True, dipsomania in the human may have complex social, libidinal and regressive connotations not present in the elemental "unconscious" of the cat, but these higher symbolizations neither negate nor conflict with the phenomena dealt with in our experiments and may, in the last analysis, be themselves reduceable to simpler biodynamic terms.*

Summary

Certain biodynamic principles governing the motivations, conditions, expressions, and vicissitudes of behavior may be derived both from animal experimentation and from the study of human conduct. Of special interest to the present discussion is the principle that neurotic behavior appears when motivations are counterposed so that their corresponding adaptive patterns became conflictful. Alcohol, in moderate doses, disorganizes complex, recently learned response-patterns, whether normal or neurotic, and thereby releases earlier and more elemental forms of goal-directed behavior. These ameliorative effects of the drug are sometimes sought by animals that have experienced them, and may, in such instances, be of significance in the biodynamic and clinical relationships bewteen neuroses and alcoholism.

* For a documental discussion of this subject, see **Masserman, J.** Neuroses and Alcohol, Amer. J. Psychiat., Jan. 1945.

REPORT OF THE ANNUAL MEETING

DECEMBER 14, 1944

The 127th Annual Meeting of the Academy for the election of Officers, Fellows and Honorary Members, the presentation of reports and the transaction of other business was held at The American Museum of Natural History on the evening of Thursday, December 14.

The Corresponding Secretary reported that there are now 45 Honorary Members upon the rolls of the Academy. The deaths of five Honorary Members and one Corresponding Member were reported during the past year.

The Recording Secretary's report stated that the Academy has held 30 Regular Sectional Meetings at which 45 stated papers of high scientific caliber were presented. In addition, two excellent addresses were delivered on the occasion of the Annual Business Meeting.

Eighteen informal receptions were held under the auspices of the various Sections of the Academy.

Three two-day conferences, on special subjects of research, were held during the year and were attended by outstanding investigators in these fields. The titles of the conferences are as follows: Section of Biology, "Animal Colony Maintenance"; Section of Physics and Chemistry, "Energy Relationships in Enzyme Reactions," "The Diffusion of Electrolytes and Macromolecules in Solution."

Six Honorary Life Members, 2 Life Members, 5 Sustaining Members, 129 Active Members, 56 Associate Members and 6 Student Members were added to the rolls, of which 200 are now in good standing and 4 await qualification through payment of dues. Thus, a total of 204 new Members was added during the year. Two Sustaining Members were transferred to Life Membership, having paid dues for twenty-five years. There are at present upon the rolls of the Academy 2,076 Members, of whom 311 are Fellows, classified as follows: 1 Patron, 92 Life Members, 122 Sustaining Members, 1,163 Active Members, 622 Associate Members, 31 Student Members, 45 Honorary Life Members.

The Editor reported that, since the last Annual Meeting, The New York Academy of Sciences published 1,022 pages to date. Of this amount, 474 pages are published in the Annals, 202 pages in the Porto Rico Survey and 346 pages in the Transactions. In addition to the

articles already published, Articles 1 and 2 of Volume 46 are in the hands of the Editor and are being prepared for the printer.

The detailed list of the publications issued during the year is as follows:

ANNALS

Volume 44, Article 6—"Psychosomatic Disturbances in Relation to Personnel Selection" by Lawrence K. Frank, M. R. Harrower-Erickson, Lawrence S. Kubie, Gardner Murphy, Donal Sheehan, and Harold G. Wolff. Pages 539–624. Published December 22, 1943.

This completes Volume 44

Volume 45, Article 2—"Lycaenidae of the Antilles," by William P. Comstock and E. Irving Huntington. Pages 49–130. Published December 29, 1943.

Volume 45, Article 3—"New Methods in Stellar Dynamics," by S. Chandrasekhar. Pages 131–162. Published December 31, 1943.

Volume 45, Article 4—"Studies on Fresh-Water Bryozoa. XIV. The Occurrence of *Stolella indica* in North America," by Mary D. Rogick. Pages 163–178. Published December 31, 1943.

Volume 45, Article 5—"The Social Behavior of the Laughing Gull," by G. K. Noble and M. Wurm. Pages 179–220. Published December 31, 1943.

Volume 45, Article 6—"Experimental Modification and Control of Molts and Changes of Coat-Color in Weasels by Controlled Lighting," by Thomas H. Bissonnette and Earl E. Bailey. Pages 221–260. Published April 7, 1944.

Volume 45, Article 7—"The Distribution of the Salamanders of the Genus *Plethodon* in Eastern United States and Canada," by Arnold B. Grobman. Pages 261–316. Published May 9, 1944.

Volume 45, Article 8—"The Organization of The New York Academy of Sciences." Revised to August 1, 1944 by Eunice Thomas Miner, Executive Secretary. Pages 317–356. Published September 7, 1944.

Volume 45, Article 9—"Energy Relationships in Enzyme Reactions," by Joseph S. Fruton, Eric G. Ball, Max Bergmann, Herman M. Kalcker, Otto Meyerhof and Carl V. Smythe. Pages 357–436. Published November 10, 1944.

This completes Volume 45

PORTO RICO SURVEY

Volume 12, Part 4—"Insects of Porto Rico and the Virgin Islands—Rhopalocera or Butterflies," by William P. Comstock. Pages 421–622. Published October 12, 1944.

TRANSACTIONS

Series II, Volume 6, Nos. 1–8, consisting of 346 pages, was completed, printed and distributed each month from November, 1943 to June, 1944 inclusive.

The Librarian reported that, the Academy has distributed, in response to requests and orders, 38,993 separate publications and 2,169 complete volumes of Transactions, Series II, as follows: *Annals*, 32,943; *Scientific Survey of Porto Rico and the Virgin Islands*, 891; *Special Publications*, Volume I, "Climate and Evolution," 121; Volume II, "Balinese Character," 251; and *Transactions*, Series II, Volume 5, com-

plete volumes, 2,169, and 4,787 single copies.

The Library of the Academy has received from exchange institutions, 1,295 separate publications.

The Treasurer reported that the Academy has just completed the most successful financial year in its history, in its receipts from membership support and sales of publications.

The total income received from all sources amounted to $26,626.53. This is an increase of $1,197.37 above that of 1943.

The Academy has added 204 new names to its rolls thus adding a gain of $900.30 to our revenue from membership dues, making a total of $8,745.30 from this source.

Receipts from sales of publications amounted to $8,253.66, an increase of $2,830.50 over that of last year.

The income from investments, amounting to $3,696.13 represents a yield slightly less than 4.6%.

A contribution of $1,500 was received from Mr. William Otis Sweet, a Sustaining Member of the Academy, who requested the establishment of the William Otis Sweet Fund, the exact definition of which is to be made later.

Included in the debit balance of $1,905.30 of the Surplus Account is $633.29 carried over from 1943; $1,001.93 covering advance payments on publications which will be charged against publication funds in 1945; and, $270.08, the balance remaining when all further payments on account were terminated by the Bank of United States in Liquidation. This latter amount was written off the Academy's books by Council authority.

The book value of the Academy's property, as of November 30, 1944, now amounts to $84,878.61; of which $76,615.89 is in stocks and bonds; $867.25 is a mortgage bond; and the remainder, $6,567.35 is represented by cash in bank, a portion of which is awaiting reinvestment.

The books of the Treasurer were duly checked and balanced at the end of the fiscal year, November 30, 1944, and have been audited by the Finance Committee, as provided by the Constitution and By-Laws.

The property of the Academy was verified and the Treasurer's report examined and attested by the Finance Committee, as of December 6, 1944.

The A. Cressy Morrison Prizes of two hundred dollars each, for the

two most acceptable papers in any field of natural science, within the scope of the Academy and its Affiliated Societies, were awarded to the following papers, entitled:

"The Effect of Activity on the Latent Period of Muscular Contraction," by Alexander Sandow, Department of Biology, New York University, New York, New York.

"A Hitherto Undemonstrated Zoogleal Form of *Mycobacterium tuberculosis*," by Eleanor Alexander-Jackson, Department of Public Health and Preventive Medicine, Cornell University Medical College, New York, New York.

The two following papers, because of their general excellence, were awarded Honorable Mention by the Committee of Judges:

"Respiration and Germination Studies of Seeds in Moist Storage," by Lela V. Barton, Boyce Thompson Institute for Plant Research, Yonkers, New York.

"An Early Site in Cayuga County, New York; Type Station of the Frontenac Focus, Archaic Pattern," by William A. Ritchie, Rochester Museum of Arts and Sciences, Rochester, New York.

The Prize Committee begs to congratulate the authors of these papers, on behalf of the Academy.

The Committee takes great pleasure in announcing that Mr. Morrison has renewed his offer of two additional prizes in Natural Science, of $200 each, for the two most acceptable papers in a field of science covered by the Academy or an Affiliated Society, to be awarded in December, 1945. The terms of competition will be published in the next issue of the *Transactions*.

The following members were elected to Fellowship:

Theodore Mead Abel, Ph.D.
Jerome Alexander, M.S.
M. L. Anson, Ph.D.
Conrad Arensberg, Ph.D.
Harriet Babcock, Ph.D.
Boris A. Bakhmeteff, C.E., D.E.
R. Bowling Barnes, Ph.D.
Charles H. Behre, Jr., Ph.D.
William C. Boyd, Ph.D.
Arthur M. Buswell, Ph.D.
Eben J. Carey, Sc.D., M.D.
Edward H. Cox, D.Sc.
H. Jermain Creighton, Sc.D.
John R. Dunning, Ph.D.
Isidore Fankuchen, Ph.D.
Joseph S. Fruton, Ph.D.
Lester H. Germer, Ph.D.
E. Newton Harvey, Ph.D.
Ethel Browne Harvey, Ph.D
Elvin A. Kabat, Ph.D.
Vladimir Karapetoff, D.Mus., Sc.D.
George E. Kimball, Ph.D.
Edwin Kirk, Ph.D.
Maurice E. Krahl, Ph.D.
George Lawton, Ph.D.
Otto Marburg, M.D.
Herman F. Mark, Ph.D.
Valy Menkin, M.D.
Howard C. Moloy, M.D.
Hans Neurath, Ph.D.
Willard Z. Park, Ph.D.
Edith H. Quimby, Sc.D.
Marie Reimer, Ph.D.
Robert Simha, Ph.D.
Maude Slye, Sc.D.
H. B. Van Dyke, Ph.D., M.D.

Honorary Life Membership was conferred upon the following eminent scientists:

Robert H. Lowie, Anthropology. Professor of Anthropology, University of California, Berkeley, California. Ph.D., Columbia University, 1908; Sc.D., University of Chicago, 1941.

Paul Niggli, Mineralogy, Petrography. Professor, Mineralogy, Zurich University and Federal Institute of Technology. Diploma in Natural Sciences; Ph.D., University of Zurich; Dr. Eng. (H.C.), Ehrenbürger technische folkschule, Carlsruhe, Zurich, 1933; D.Sc. (H.C.), Technische folkschule, Stuttgart, 1933; D.Sc. (H.C.), University of Geneva, 1935; D.Sc. (H.C.), University of Budapest. Research Fellow, Carnegie Institution of Washington. Awarded Silver Medal in Sciences, Federal Institute of Technology; President, Geotechnical Commission of the Swiss Society for Natural Science Research.

Florence Sabin, Anatomy, Pathology. Member, Rockefeller Institute for Medical Research, 1925–38, Emeritus Member, 1938–, New York, N.Y. Sc.D., Smith College, 1910; M.D., Johns Hopkins Medical School, 1900; Sc.D., University of Michigan, 1926; Mt. Holyoke College, 1929; New York University, 1933; Wilson College, 1933; University of Syracuse, 1934; Oglethorpe University, 1935; University of Colorado, 1935; University of Pennsylvania, 1937; Oberlin College, 1937; Russell Sage College, 1938; LL.D., Goucher College, 1931. Awarded National Achievement Award, 1932 and M. Cary Thomas Prize, Bryn Mawr, 1935.

The following officers were elected for the year 1945:

For President

WALTER H. BUCHER

For Vice-Presidents

MARSHALL KAY — RAYMUND L. ZWEMER

ANNE ROE — JOSEPH S. FRUTON

HORTENSE POWDERMAKER — RAYMOND B. MONTGOMERY

For Recording Secretary

MICHAEL HEIDELBERGER

For Corresponding Secretary

H. HERBERT JOHNSON

For Treasurer

DONALD BELCHER

For Librarian

BARNUM BROWN

For Editor

ROY W. MINER

For Councilors (1945–1947)

RALPH H. CHENEY

ROBERT CUSHMAN MURPHY — HERBERT F. SCHWARZ

For Finance Committee

HARDEN F. TAYLOR, *Chairman*

HARRY B. VAN DYKE — ADDISON WEBB

After the Business Meeting, the following address was delivered by the speaker of the evening:

"Polymers and Light"

by

PETER DEBYE

Professor of Chemistry, Cornell University

(Illustrated)

Polymers are giant molecules, although in general still too small to be seen with an ordinary microscope. Their unusual size or shape together with a peculiar flexible structure, which many of them possess, are mainly responsible for outstanding technical properties of the finished product (Example: Rubber). When light passes through a solution of such polymers a small part is scattered analogous to the part of the sunlight scattered in our atmosphere, giving us the impression of a blue sky. The address deals with the answer to the question as to how measurements on the strength and distribution of the scattered light from polymer solutions can be used to determine size and shape of these invisible particles.

(*Abstract by the Speaker*)

ALEXANDER SANDOW, Department of Biology, Washington Square College of Arts and Science, New York University: ***The Effect of Activity on the Latent Period of Muscular Contraction.**** (A. Cressy Morrison Prize Winner, 1944.) (Abstract.)

This research deals with the effects of a muscle's activity on the various features of that part of the contractile response known as the mechanical latent period—the time interval between the instant of application of a stimulus to the muscle fibers and the instant at which the first sign of tension development appears. In frog skeletal muscle, this interval lasts about 3 ms. Since a burst of contractile activity of a muscle not only alters the latency behavior in subsequent contractions, but also causes marked and quite well-known changes in the muscle's internal chemical milieu, the possibility arises of attempting to elucidate the nature of the latent period in the light of the correlation between the activity-induced latency and chemical effects.

The latest period is not, as has been generally thought, a time of complete mechanical quiescence. It was first demonstrated by Rauh, in 1922, that a frog skeletal muscle actually relaxes very slightly during the latter part of its latent period, just prior to the development of tension. This "latency relaxation" (abbreviated LR) involves a maximum negative tension change in frog sartorii of 10–20 mg., i.e., only about 0.05% of the positive tension at the peak of a twitch. This is so minute—the equivalent LR increase in muscle length being only about 0.1 μ—that even the most sensitive mechano-optical muscle registering levers can hardly do more than detect the change. It has therefore been necessary to devise for the present research a new, electronic, method for recording the LR. This involves the conversion of the latency mechanical events into an electric pulse by means of a piezoelectric pickup (actually the working unit of a crystal phonograph pickup) and the amplification of this pulse so as to actuate a cathode-ray oscillograph. The apparatus is in effect an electronic lever which, with a magnification factor of about 500,000× presents the minute LR pre-contractile elongation as a deflection of some 5 cm. on the cathode-ray screen. Measurement of photographs of such deflections permit LR alterations to be determined with a precision of $\pm$ 0.1 mg. tension, or equivalent $\pm$ 0.002 μ length, change. A time calibration

* Research supported in part by a grant from the Penrose Fund of the American Philosophical Society.

impressed on each latency record enables time intervals to be read with a precision of ± 0.02 ms.

All the experiments of the present study have been done on frog sartorii suspended, under an initial tension of about 3 gm., in the moist air of a muscle chamber at temperatures of from 22° to 25° C. The muscles have been activated by either a tetanus, a series of tetani, a series of twitches, or certain combinations of these, and the corresponding latency changes determined.

It has been found that activity in any amount, even a single twitch, causes an immediate reduction in R, the depth of the LR. The greater the extent of the activity, the greater is the decrease in R, so that, after a series of, say, fifteen 2 sec. tetani, R is reduced to about 10% of its pre-activity value. The time interval between the instants of stimulation and of the beginning of the latency relaxation, L_R, is not affected by activity unless the muscle has been brought to a stage of advanced fatigue, when L_R tends to increase.

The results concerning the latency for positive tension development —the true mechanical latent period—, L_T, are more complex. (Actually, L_T consists of a set of three latencies, each measured from the instant of stimulation to a particular instant within the time during which the LR develops and is reversed by the earliest increments of tension rise. These L_T's, however, always vary in parallel and, for the present needs, it is not necessary to distinguish between them. L_T will therefore be used here to symbolize the duration of the mechanical latent period.) Due to slight activity, 5 or 6 successive twitches at 3 sec. intervals, L_T increases by at most 0.2 to 0.3 ms; further activity, amounting to 4 or 5 successive 2 sec. tetani, then causes L_T to decrease by as much as 0.5 ms.; any still further activity results in increases in L_T up to or even beyond the original pre-activity values. All of the activity changes listed above are, in general, reversed by rest.

It is known that the LR is a function of myosin, the contractile protein, and the present research proves, furthermore, that the changes in the latency variables caused by activity are not due to effects on the excitatory aspects of the response, which, if they occurred, might conceivably be reflected in contractile modifications, but are due to the direct effect of the activity on some feature of the contractile complex of the muscle.

In searching for the particular contractile feature that is involved, the interpretation of the results concerning R and L_R have not been

very helpful. The L_T results, however, are very suggestive. The changes in L_T, due to activity and subsequent rest, show a striking correlation with the course of the pH changes that other workers have demonstrated in frog muscles activated similarly to those in our experiments. The general conclusion derivable from this correlation is that the tension latency is shorter, the higher the pH of the muscle. It thus follows that the rate of some process that is directly involved in determining the speed of tension rise is greater, the more alkaline the muscle. Since the hydrolysis of adenosine-triphosphate (ATP), undoubtedly an important source of energy for muscular processes, is known to increase in rate with increase in pH (up to about pH 9.0), and since other relevant muscle reactions do not have this property, it is inferred that the hydrolysis of ATP is the process that directly determines the rate of rise of tension. This inference thus indicates that the energization of myosin, the contractile protein, occurs during the activation (i.e., latent and contraction) periods of a muscular response, and not, as some believe, during the recovery phases of the response. Furthermore, this inference, and some other implications of the data, are shown to be in accord with a particular conception of the energizing mechanism in muscle previously proposed by the author, that the LR is a mechanical sign of a tension-induction process involving coupling in the form of an enzyme-substrate combination of myosin and ATP during the existence of which the energy of the first phosphate bond of the ATP is transferred to the myosin, thus energizing it and activating it for contraction.

ELEANOR ALEXANDER-JACKSON, Department of Public Health and Preventive Medicine, Cornell University Medical College: *A Hitherto Undemonstrated Zoogleal Form of Mycobacterium Tuberculosis.* (A. Cressy Morrison Prize Winner, 1944.) (Abstract.)

The existence of non-acid-fast forms of *Mycobacterium tuberculosis* has been recognized at least as far back as 1900, but the reproductive role played by them has been variously interpreted by many observers. At the present time, there are four main schools of thought.

The first school regards non-acid-fast rods and granules as degenerative in nature since they are to be found in old cultures, and the supporters of this view claim that they were unable to observe any mode of reproduction other than binary fission.

The second school includes those who believe in the filterability of certain elements of this organism.

The third school includes those who, while unable to demonstrate filterable forms, are of the opinion that the non-acid-fast rods and granules are in many instances young organisms which have not as yet developed acid-fastness, but later on develop into acid-fast rods. The adherents of this latter group agree that binary fission may be the common method of reproduction, but find that non-acid-fast granules, obtained through segmentation, either elongate or sprout into the rod forms of *Mycobacterium tuberculosis.*

Finally, there is a group that regards non-acid-fast forms, in many instances, as artifacts brought into being by injury suffered by the microtome knife or by manipulative damage with the platinum loop in preparing slides for staining. The conclusions drawn from their work are vitiated by the fact that the authors describe a technic so different from those usually employed in producing stained preparations that no comparison can be made.

In this paper, the author demonstrates that:

Mycobacterium tuberculosis can exist not only as rods or granules, but also as a zoogleal plasmodium consisting of granules or larger globoid bodies surrounded or enmeshed by amorphous material.

These zoogleal forms are not revealed by the usual stain technics (unless acid-fast). They are made observable by a new staining technic described by the author.

Zoogleal forms have been observed repeatedly in unstained material, as well as in preparations stained by the triple stain method.

Single-cell studies and electron microscope photographs of materterial from pure cultures, indicate that zoogleal forms, under suitable environmental conditions, are able to revert to rod forms and *vice versa*.

It has been observed that diphtheoids are also able to enter a zoogleal state, and to revert to rod forms.

The demonstration of forms which are not revealed by the usual technic, may throw some light on the question of the apparent disappearance of acid-fast bacilli or their paucity during the course of some tuberculous infections.

Much additional work with both pure cultures and clinical material is necessary to understand more fully the part played by the zoogleal forms in tuberculous infection. We still do not know just what happens to the organisms when acid-fast bacilli disappear from sputum in arrested cases, only to reappear in large numbers with the return of active disease. Are most of them destroyed, or does a portion of them undergo a dissociative change in response to an environment temporarily unfavorable to the maintenance of the characteristic rod form of *Mycobacterium tuberculosis?* Another mystery is the difficulty, at times, of finding any acid-fast bacilli in stained preparations from pathological material where one would expect to find many. Frequently a definite diagnosis of tuberculosis is delayed by failure to find typical red-staining rods until some time after the first laboratory examination.

In approaching these problems, the writer is only too well aware of the great difficulties which lie along the path, a path made thorny by the ever present danger of confusing the "real thing" with nontuberculous elements—in particular, the diphtheroids. The utmost care, therefore, was taken to exclude their presence, and to maintain a stoic skepticism until repeated close observations had been made. The work described above covers a ten-year period.

LELA V. BARTON, Boyce Thompson Institute for Plant Research, Inc.:
Respiration and Germination Studies of Seeds in Moist Storage."
(Honorable Mention, A. Cressy Morrison Prize Competition, 1944.) (Abstract.)

There are many published reports of seeds that were supposed to have been buried in the soil for decades and yet remained dormant and viable. Most of these accounts have been based on the appearance of plants not common to the region on newly excavated or plowed soil. Similar observations have been made recently for bombed areas in Great Britain. Any gardener will testify to the continued reappearance of weeds in his garden in spite of careful elimination of the seedlings as they appear year after year. The results of controlled seed burial tests conducted by several workers have confirmed these general conclusions. This means that the soil is stocked with seeds which are capable of germination when they are disturbed. Some of these seeds which possess hard coats finally germinate when fungi and bacteria or low temperature have caused the deterioration or the cracking of the impermeable part of the coat. Many other seeds, especially weeds, which do not have hard coats remain fully imbibed in the soil for long periods. *Amaranthus* and *Rumex* are among the latter. They have been shown to remain viable under these conditions for forty years. Their dormancy or failure to germinate must be due to a very delicate equilibrium, for it can be overcome by many factors, such as light, fluctuating temperatures of the top soil, mechanical disturbance, or oxygen supply. When seeds take up water preparatory to germination, their metabolic activities become greatly accelerated. It is evident that imbibed seeds could not remain viable very long in the soil unless definite curtailment of these activities took place. No actual measurement of this curtailment has ever been reported.

Respiration studies on seeds of *Amaranthus retroflexus* L., *Rumex obtusifolius* L., and *Impatiens balsamina* L., held moist and without germination, were conducted. This involved the development of a new technique to permit the measurement of the oxygen consumed and the carbon dioxide evolved by dormant seeds. Germination tests, the results of which demonstrated the delicate nature of the mechanism imposing such dormancy, are also included.

Gaseous exchange of *Amaranthus retroflexus* seeds, measured at intervals of from 0 to 901 days of moist storage at 20° C., showed at least a ten-fold reduction in respiration. The beginning of this reduc-

tion became apparent very early (after two days), and was definite after eight days in moist storage. Decreased respiration was also noted for *Impatiens balsamina* seeds held moist at 20° C. for 28 to 365 days. With increased length of time in moist storage, the respiratory quotient decreased.

Seeds of *Amaranthus retroflexus* held in moist storage showed a periodicity in germination which was apparently independent of external conditions. This indicated varying degrees of the primary dormancy or the induced secondary dormancy of the original lot of seeds. Moist *Amaranthus* seeds held without germination at 20° C. could be induced to germinate at that same temperature by rubbing, by drying for three hours to three days, or by exposure to 35° C. for 2 to 24 hours. Germination also proceeded immediately after removal to higher constant or alternating temperatures.

Moist seeds of *Rumex obtusifolius*, held without germination at 30° C., could be made to germinate at this same temperature by removal of the coats, treatment with concentrated sulphuric acid for two minutes, or exposure to 5° C. for four days. Upon removal from 30° C. to lower constant temperatures or daily alternating temperatures, germination proceeded without further treatment.

Many variable factors which doubtless affect the life span of seeds in soil were not present in the controlled experiments reported here. However, these studies indicate some of the fundamental changes which take place in seeds during moist storage and may serve as a beginning for further investigations.

WILLIAM A. RITCHIE, Rochester Museum of Arts and Sciences: *An Early Site in Cayuga County, New York; Type Station of the Frontenac Focus, Archaic Pattern.* (Honorable Mention, A. Cressy Morrison Prize Competition, 1944.) (Abstract.)

This paper constitutes the formal report of two seasons (1939–1940) of excavation work conducted by the writer on an archaeological site of exceptional richness and significance to New York prehistory. His previous researches in the state had defined two discrete archaeological horizons (Lamoka and Brewerton Laurentian) pertaining to a prehorticultural and preceramic time-level, designated the Archaic, with vague suggestions of a partial temporal overlap. At Frontenac Island, there appeared, for the first time, clear evidence of the contact of these different peoples and cultures, resulting in a composite new culture, termed the Frontenac Focus of the Archaic Pattern.

The materials found and presented for analysis included nearly 2,000 industrial artifacts (from midden and graves), 159 human burials, and numerous other features, as dog burials, hearths, pits, and simple stone structures.

Typological studies of the midden artifacts and site histograms to show their distribution revealed the occurrence of a superficial upper zone congeries, undifferentiated by physical stratigraphy, which pertained to a relatively little known culture termed the Point Peninsula Focus. The genetically unrelated culture of the much deeper lower zone proved, on analysis, to be composed very largely of the diagnostic and linked traits of the Lamoka (28.8%) and Brewerton Laurentian (25.8%) cultures, with the addition of 20.4% of novel traits. Detailed distributional studies showed for this complex no variation in typology as a function of depth; hence, the Archaic level of the site appeared to indicate, not a succession of the constituent cultures, but an amalgamation thereof, pertaining essentially to one time horizon.

The assessing of the mortuary data (belonging almost exclusively to the Archaic occupation) for their contribution to the interpretation of the site involved the ascertaining of correlations relative to (1) mode and order of burial; (2) craniological character of the restorable and mensurable skulls (45 in number); and (3) occurrence and typology of mortuary or grave goods. The following facts were established: (1) All modes of inhumation noted, viz., flexed, extended, crema-

tion, and bundle, were simultaneously practiced throughout the Archaic time range, as determined by multiple and superimposed burials. (2) Three cranial groups, which may be designated the dolichocranial (group 1), mesocranial (group 2), and brachycranial (group 3), were metrically and indically distinguished. The first is characteristic of the Lamoka Focus, the third of the Brewerton Laurentian Focus, the second seems to be the hybrid product of miscegenation. A morphological analysis of the entire series shows two distinct types: type 1, conforming to the Indian Knoll Sylvids; type 2, provisionally of the Younge type Sylvids (both typed by Neumann). Group 1 and type 1 correlate perfectly, as do group 3 and type 2. Both types occur in the mesocranial, group 2.

A moderate degree of correlation exists between physical type and burial mode. Type 1 skulls were associated with nearly twice as many flexed burials as type 2 skulls, and, conversely, type 2 crania occurred with one-third more extended skeletons than did type 1 crania.

Some correlation also is evident when burial mode, physical form, and typology of grave goods are considered. Grave goods of Lamoka culture were associated principally with flexed burials and type 1 crania, grave goods of Brewerton Laurentian type occurred almost exclusively with extended burials and type 2 crania, while grave goods combining deterministic traits of both the Lamoka and Brewerton Laurentian foci were found only with extended burials producing skulls of both morphological types.

Several alternative hypotheses were tested in the light of the complete analytical data, resulting in the following conclusions: The lower component at Frontenac Island represents the composite product of two discrete Archaic cultures of the New York area, Lamoka and Brewerton Laurentian, with their equally distinctive ethnic correlates; but, within this mixed population, cultural integration (as well as physical amalgamation) was not complete, old traits and customs still in part prevailing in combination. There seems also to have been some dominance of the Brewerton Laurentian complex over the simpler and probably older Lamoka paradigm.

Not only does the Frontenac Focus bridge the hiatus in our Archaic sequence, but it also discloses the earliest appearance of a number of constituent traits of the later Woodland and Hopewellian manifestations. It may also be compared profitably with the Shell-Mound Aspect of the Archaic Pattern of the southeastern United States.